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## ORIGINAL ARTICLE

# Elective laparoscopic recto-sigmoid resection for diverticular disease is suitable as a training operation

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## Abstract

**Purpose** Some authors state that elective laparoscopic recto-sigmoid resection is more difficult for diverticular disease as compared with malignancy. For this reason, starting laparoscopic surgeons might avoid diverticulitis, making the implementation phase unnecessary long. The aim of this study was to determine whether laparoscopic resection for diverticular disease should be included during the implementation phase.

**Methods** All consecutive patients who underwent an elective laparoscopic recto-sigmoid resection in our hospital for diverticulitis or cancer from 2003 to 2007 were analysed.

**Results** A total of 256 consecutive patients were included in this prospective cohort study. One hundred and fifty-one

patients were operated on for diverticulitis and 105 for cancer. There was no significant difference in operation time (168 vs. 172 min), blood loss (189 vs. 208 ml), conversion rates (9.9% vs. 11.4%), hospital stay (8 vs. 8 days), total number of peroperative (2.3% vs. 1.6%) or postoperative complications (21.9% vs. 26.9%). The occurrence of anastomotic leakages was associated with higher American Society of Anesthesiologists (ASA) classification, which differed between the groups (86.8% vs. 64.8% ASA I–II,  $p < 0.001$ ).

**Conclusion** Since there are no differences in operation time, blood loss, conversion rate and total complications, there is no need to avoid laparoscopic recto-sigmoid resection for diverticular disease early in the learning curve.

**Keywords** Laparoscopy · Colon cancer · Diverticular disease · Recto-sigmoid resection · Teaching · Malignancy

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## Introduction

Since its introduction in 1991 in clinical practice, laparoscopic colorectal surgery is growing in popularity [1]. General benefits of the laparoscopic approach compared to open surgery include reduced blood loss, fewer adhesions, less pain, decreased risk of incisional hernia, shorter hospital stay, better cosmesis and a faster return to normal activities [2–5].

The majority of indications for laparoscopic colorectal surgery concern resections of the sigmoid colon for either cancer or diverticular disease. A number of multicentre randomised controlled trials have demonstrated equivalent outcomes for cancer compared with open surgery [6–8]. Recently, Lacy et al. reported a long-term survival benefit for laparoscopy-assisted colectomy for cancer compared with open colectomy [9]. Laparoscopic resections for (post)

diverticular disease were shown to be feasible as well [10–12]. Despite the feasibility and advantages of laparoscopic resection for diverticular disease, some experts have voted their concern that due to the inflammatory process, the technical skills are more demanding [13]. This raises the question if the laparoscopic treatment of diverticular disease should be included in the initial training phase or not.

Implementation of the technique of laparoscopic colonic resection requires special training. The learning curve for laparoscopic colorectal resections is long with a reported range from 15 to 70 procedures [14, 15]. It is, therefore, important to be exposed to as many procedures as possible during the training phase. Both the American Society of Colon and Rectal Surgeons and the Society of American Gastrointestinal Endoscopic Surgeons state that at least 20 laparoscopic colorectal resections with an anastomosis for benign disease or metastatic cancer should be performed before using the technique to treat curable cancer [16]. To start laparoscopic surgery with benign colon diseases is a save policy, although based on expert opinions only. Furthermore, it is not always clear whether these first operations are performed under strict direct supervision of an expert laparoscopist. The hypothesis in this study is that operating benign inflammatory disease and cancer under strict supervision is equally safe and improves exposure for the trainee and, therefore, probably speeds up the learning curve without jeopardising the patients.

This was assessed in a prospective case series. We analysed the outcome of laparoscopic recto-sigmoid resections for diverticular disease and for cancer.

## Materials and methods

All consecutive patients who received an elective laparoscopic colorectal resection from January 2003 through

December 2007 in a large teaching hospital (Medical Center Leeuwarden) were prospectively entered into a web-based database and analysed. In this study, all patients with an elective laparoscopic recto-sigmoid resection for diverticular disease were compared with patients with the same elective resection for malignancy. There were no exclusion criteria for laparoscopy in both groups.

All operations were performed by residents or trainee surgeons who had performed less than 15 laparoscopic colorectal resections. All operations were directly supervised by one of four surgeons with an experience of at least 100 laparoscopic colorectal procedures at the time of the study.

The following data were collected: age, gender, body mass index (BMI), date of operation, date of discharge, operation team (resident, trainee or staff surgeon), the American Society of Anesthesiologists (ASA) classification, use of immunosuppressive medication, diabetes, previous laparotomy, malignancy, diverticular disease, stoma formation, blood loss, operation time, peroperative complications (bleeding, stapler problems, damage to adjacent organs, other), conversion (defined as an unplanned laparotomy or any incision extended longer than needed solely for extraction of the specimen), postoperative complications (anastomotic leakage, cardiovascular, respiratory, other), radiological reintervention, relaparotomy, relaparoscopy, TNM stage in case of a malignancy and mortality within 30 days of the index operation.

Indications for elective surgery in diverticular disease were more than two episodes of diverticulitis, stenosis or fistula following diverticulitis. A recto-sigmoid carcinoma was defined as an adenocarcinoma found in a tumour at colonoscopy in the recto-sigmoid colon. The tumour should be projecting above the line between the pubic symphysis and the promontory as assessed by radiological studies.

**Table 1** Patient characteristics

	Diverticular disease ( <i>n</i> =151)	Malignancy ( <i>n</i> =105)	<i>p</i> -value	Test value	DF
BMI	26 (SD 4.14)	26 (SD 4.16)	0.807 <sup>a</sup>	−0.245	246
Previous laparotomy	55 (36.4%)	29 (27.6%)	0.140 <sup>b</sup>	2.178	1
Immunosuppressive medication	7 (4.6%)	5 (4.8%)	0.963 <sup>b</sup>	0.002	1
Malnutrition	5 (3.3%)	6 (5.7%)	0.351 <sup>b</sup>	0.870	1
Age	58 (SD 13.07)	66 (SD 11.29)	<0.001 <sup>a</sup>	−5.156	254
Gender male/female	70/81	68/37	0.004 <sup>b</sup>	8.443	1
Diabetes	5 (3.3%)	10 (9.5%)	0.037 <sup>b</sup>	4.333	1
ASA 1–2 vs. ASA 3–4	131 (86.8%): 20 (13.2%)	68 (64.8%): 37 (35.2%)	<0.001 <sup>b</sup>	17.308	1

Data presented as mean and standard deviation (SD) or counts with percentage in brackets

DF degrees of freedom

<sup>a</sup> *t* test

<sup>b</sup> Chi-square test

**Table 2** Operative data

	Diverticular disease ( <i>n</i> =151)	Malignancy ( <i>n</i> =105)	<i>p</i> -value	Test statistic value	DF
Operation time	168 min (86–450)	172 min (95–360)	0.277 <sup>a</sup>	−1.087	NA
Blood loss	189 ml (10–2,700)	208 ml (10–1,500)	0.197 <sup>a</sup>	−1.291	NA
Conversion rate	9.9%	11.4%	0.702 <sup>b</sup>	0.147	1
Hospital stay	8 (2–65) days	8 (3–75) days	0.121 <sup>a</sup>	−1.551	NA

Data presented as median and range or as percentage

DF degrees of freedom, NA not applicable

<sup>a</sup> Mann–Whitney *U* test

<sup>b</sup> Chi-square test

We used the same standardised operation technique for both diverticular disease and malignancy. We prefer a standardised technique not only from an educational point of view but also because we think that operating in anatomical planes especially in inflammatory disease with infiltration will have less risk for damaging the ureter or other adjacent structures. We always apply ligation of circulation at the level of the superior rectal artery (low tie) just caudal of the left colic artery since this is anatomically less invasive with respect to circulation and preserves the autonomous nerves at the root of the inferior mesenteric artery which might be at risk when using a high tie. Oncologically, there is no difference in high or low tie resections [17]. No preoperative selection of patients was performed, and all recto-sigmoid resections were started laparoscopically. Our laparoscopic technique has been previously described in detail [18].

#### Statistical analysis

All data were entered into a database and analysed with SPSS statistical software (version 14.0 for Windows; SPSS, Chicago, IL, USA). Statistical analysis was performed using the Student's *t* test, chi-square test or Mann–Whitney *U* test to determine significant differences between groups. A *p*-value of  $\leq 0.05$  was considered statistically significant.

#### Results

From January 2003 through December 2007, a total of 256 consecutive patients received an elective laparoscopic recto-sigmoid resection. During this period, 151 patients were operated on for diverticular disease (group 1) and 105 for malignancy (group 2). See Table 1 for the patient characteristics for each group.

In the diverticular disease group, recurrent diverticulitis (56%), stenosis (40%) and fistula (4%) were the indications for surgery.

As shown in Table 2, there were no significant differences between the groups in operation time, blood loss, conversion rates or hospital stay between the two groups. The odds ratio of conversion for diverticular disease versus malignancy was 0.86 (95% confidence interval, CI, 0.38–1.9). In the malignancy group, a median of 10 (range 2–49) lymph nodes was obtained for further analysis.

Reasons for conversion are outlined in Table 3. The most notable reasons were: adhesions, advanced disease and no visualisation of critical structures. The data on perioperative and postoperative complications are given in Tables 4 and 5. The total number of perioperative complications did not differ between the two groups (group 1 2.3% vs. group 21.6%, odds ratio 1.04, 95% CI 0.29–3.8). In the diverticular group, the small bowel was damaged once during an open

**Table 3** Reason for conversion (*n*=27 out of 256)

	Diverticular disease ( <i>n</i> =15)	Malignancy ( <i>n</i> =12)
Adhesions	7	2
Advanced disease	0	4
No visualisation of critical structures	5	1
Unable to mobilise colon	1	1
Poor exposure	0	1
Inadequate margins of resection	0	1
Other	2	2

**Table 4** Peroperative complications

	Diverticular disease ( <i>n</i> =151)	Malignancy ( <i>n</i> =105)	<i>p</i> -value	Test value	DF
Total peroperative complications	6 (2.3%)	4 (1.6%)	0.947 <sup>a</sup>	0.04	1
Damage to adjacent organ	1	1	NA	NA	NA
Other preoperative complications	5	3	NA	NA	NA

DF degrees of freedom, NA not applicable

<sup>a</sup> Chi-square test

introduction making a small resection necessary. In five patients, a small serosal tear on the colon caused by the Babcock clamp was sutured during laparoscopy. The same complication occurred three times in the malignancy group and was treated in the same way. In the malignancy group, the left ureter was injured once. A double-J catheter was introduced and the ureter sutured using laparoscopy. Recovery afterwards was uneventful.

The total number of postoperative (minor and major) complications between group 1 and group 2 did not differ (Table 5). However, the incidence of anastomotic leakage was significantly higher in the malignancy group (4.0% vs. 10.5%), leading to significantly more reinterventions in this group. However, stratified analysis showed that this result was due to confounding by ASA classification (Table 6), which differed significantly between the groups. In both groups, no relaparoscopies could be performed due to postoperative distended intestines. Thus, open procedures were performed leading to a diverting ileostomy in five out of six patients in the diverticular group and in nine out of 11 in the malignancy group. Definitive end colostomies were created in the remaining three patients.

The other postoperative complications concerned mainly paralytic ileus, infections of the urinary tract and wound, which were all treated conservatively.

In the diverticular group, one patient died on the first day after surgery due to a myocardial infarction. Two patients died in the malignancy group: one patient following a cerebrovascular accident 10 days after surgery and the other patient due to anastomotic dehiscence, leading to abdominal sepsis and finally multi-organ failure.

## Discussion

Laparoscopy has gained widespread acceptance in common surgical practice. The trend towards the introduction of laparoscopic colorectal surgery is a result of the increasing evidence which demonstrate the advantages of laparoscopy over open surgery including reduced blood loss, fewer adhesions, less pain, decreased risk of long-term incisional hernia formation, shorter hospital stay, better cosmesis and a faster return to normal activities [2–5]. Specific advantages of laparoscopy in colorectal surgery include also earlier return of bowel function, better pulmonary function and better quality of life.

Nevertheless, there is much concern about the implementation of this new technique, and some surgeons are reluctant to perform laparoscopic colorectal resections because of the learning curve [14]. The Netherlands Health

**Table 5** Postoperative complications

	Diverticular disease ( <i>n</i> =151)	Malignancy ( <i>n</i> =105)	<i>p</i> -value	Test value	DF	Odds ratio (95% CI)
Total postoperative complications	33 (21.9%)	28 (26.9%)	0.374 <sup>a</sup>	0.790	1	0.77 (0.43–1.37)
Cardiovascular	2 (1.3%)	0	0.236 <sup>a</sup>	1.402	1	
Respiratory	6 (4.0%)	4 (3.8%)	0.947 <sup>a</sup>	0.004	1	1.05 (0.29–3.78)
Anastomotic leakage	6 (4.0%)	11 (10.5%)	0.040 <sup>a</sup>	4.224	1	0.35 (0.13–0.99)
Other	18 (11.9%)	11 (10.4%)	0.543 <sup>a</sup>	0.370	1	0.81 (0.42–1.58)
Surgical reintervention	8 (5.3%)	14 (13.3%)	0.024 <sup>a</sup>	5.043	1	0.36 (0.15–0.90)
Mortality	1 (0.7%)	2 (1.9%)	0.364 <sup>a</sup>	0.826	1	0.34 (0.03–3.83)

DF degrees of freedom

<sup>a</sup> Chi-square test

**Table 6** Analysis of anastomotic leakage by stratified by ASA classification

	Diverticular disease ( <i>n</i> =151)	Malignancy ( <i>n</i> =105)	<i>p</i> -value	Test value	DF	Odds ratio (95% CI)
ASA 1–2	2.3% (3/131)	5.9% (4/68)	0.192 <sup>a</sup>	1.702	1	0.38 (0.08–1.73)
ASA 3–4	15% (3/20)	18.9% (7/37)	0.710 <sup>a</sup>	0.138	1	0.77 (0.17–3.31)

DF degrees of freedom

<sup>a</sup> Chi-square test

Care Inspectorate released a report on minimal invasive surgery in the Netherlands in November 2007 [19]. They concluded that a qualitative and quantitative description of minimal invasive skills is not available in most hospitals in the Netherlands. Therefore, it may be helpful for surgeons who want to start a laparoscopic colonic resection program in their own hospital, after adequate training and certification, to find some guidelines that help to select which procedures should be learned first. In particular, some concern has been voiced in several articles because the inflammatory process of diverticular disease could make laparoscopic resection more difficult compared to resection for colorectal cancer [12–14, 20]. However, this concern has not been supported by any data. The implementation phase might be unnecessary prolonged when laparoscopic resections for diverticular disease are not included in the learning phase. Stefanidis et al. [21] investigated whether novices improved their ability to develop multitasking by accumulating experience on a simulated laparoscopic task. They found that those participants who had performed more repetitions during training had significantly better scores compared to those with fewer repetitions. Therefore, it seems reasonable to conclude that a larger number of laparoscopic recto-sigmoid resections performed in a specific period of time will lead to improved outcome in terms of surgical skills.

The hypothesis that laparoscopic recto-sigmoid resection for diverticular disease should be included in the implementation phase of laparoscopic colonic surgery was tested by comparing the results of our laparoscopic recto-sigmoid resections for diverticular disease with the same procedure for a malignancy with regard to longer operation time, more conversions, more blood loss and more postoperative complications for diverticular disease. The latter would support the concerns proposed that the elective laparoscopic resection of diverticular disease is more difficult than for a malignancy. Since all operations were performed by residents or surgeons at the beginning of their training, any difference in the two procedures should be demonstrated.

However, in this study, the data did not show any difference in operation time, blood loss or conversion rates. Our results were similar in both groups and are in

agreement with results from other studies [11, 22]. Since there are no differences in outcome related to the disease or technique, this study confirms the hypothesis that diverticular disease can be performed as safely as laparoscopic recto-sigmoid resection for a malignancy.

The patients in the malignancy group were older than the diverticular disease patients, as cancer is more a disease of the elderly as compared to diverticular disease [10–12, 20, 23]. The increased age of the patients in the malignancy group explains that more patients with ASA 3–4 and diabetes were found in this group. Despite a higher risk profile in the malignancy group, no increase in overall postoperative complications was seen. However, anastomotic leakage, one of the most devastating postoperative complications in colorectal surgery, occurred significantly more often in the malignancy group (10.5% vs. 4.0%,  $p=0.040$ ). As a result, more surgical reinterventions (13.3% vs. 5.3%,  $p=0.024$ ) were recorded in the malignancy group. Further analysis stratified for ASA classification showed that the higher ASA classification in the malignancy group was the underlying determinant for the difference in anastomotic leakage between the two groups (Table 6). ASA classification is known to be an independent risk factor for anastomotic leakage, as mentioned by previous authors [24–27].

One other study compared laparoscopic resection for diverticular disease with non-diverticular disease [20]. Although these authors also conclude from their data that laparoscopic resection can be performed with acceptable morbidity and mortality for both diverticular disease and non-diverticular disease, the indications and therapies in the non-diverticular disease group were highly heterogeneous. To our knowledge, this study is the first to compare a standardised elective laparoscopic recto-sigmoid resection for diverticular disease with the identical procedure for malignancy.

In conclusion, we state that diverticular disease and cancer can be operated by laparoscopy equally safe early in the learning curve if operated under direct supervision. By operating on both cancer and diverticular disease, the surgeon will be exposed to more procedures in a shorter time, allowing a steeper learning curve and a shorter implementation phase.



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## References

- Jacobs M, Verdeja JC, Goldstein HS (1991) Minimally invasive colon resection (laparoscopic colectomy). *Surg Laparosc Endosc* 1 (3):144–150
- Abraham NS, Young JM, Soloman MJ (2004) Meta-analysis of short-term outcomes after laparoscopic resection for colorectal cancer. *Br J Surg* 91:1111–1124
- Gutt CN, Oniu T, Schemmer P, Mehrabi A, Buchler MW (2004) Fewer adhesions induced by laparoscopic surgery? *Surg Endosc* 18:898–906
- Dowson HM, Bong JJ, Lovell DP, Worthington TR, Karanjia ND, Rockall TA (2008) Reduced adhesion formation following laparoscopic versus open colorectal surgery. *Br J Surg* 95:909–914
- Laurent C, Leblanc F, Bretagnol F, Capdepon M, Rullier E (2008) Long-term wound advantages of the laparoscopic approach in rectal cancer. *Br J Surg* 95:903–908
- Jayne DG, Guillou PJ, Thorpe H, Quirke P, Copeland J, Smith AMH, Health RM, Brown JM, UK MRC CLASSIC Trial group (2007) Randomized trial of laparoscopic-assisted resection of colorectal carcinoma: 3-year results of the UK MRC Classic trial group. *J Clin Oncol* 25(21):3061–3068
- Veldkamp R, Kuhry E, Hop WC, Jeekel J, Kazemier G, Bonjer HJ, Haglind E, Pahlman L, Cuesta MA, Msika S, Morino M, Lacy AM, Colon Cancer Laparoscopic or Open Resection Study Group (COLOR) (2005) Laparoscopic surgery versus open surgery for colon cancer: short-term outcomes of a randomised trial. *Lancet Oncol* 6:477–484
- The Clinical Outcomes of Surgical Therapy Study Group (2004) A comparison of laparoscopically assisted and open colectomy for colon cancer. *N Engl J Med* 350:2050–2059
- Lacy AM, Delgado S, Castells A, Prins HA, Arroyo V, Ibarzabal A, Pique JM (2008) The long-term results of a randomized clinical trial of laparoscopy-assisted versus open surgery for colon cancer. *Ann Surg* 248(1):1–7
- Schwandner O, Farke S, Fischer F, Eckmann C, Schiedeck TH, Bruch HP (2004) Laparoscopic colectomy for recurrent and complicated diverticulitis: a prospective study of 396 patients. *Langenbecks Arch Surg* 389:97–103
- Alves A, Panis Y, Slim K, Heyd B, Kwiatkowski F, Manton G, Association Française de Chirurgie (2005) French multicentre prospective observational study of laparoscopic versus open colectomy for sigmoid diverticular disease. *Br J Surg* 92:1520–1525
- Dwivedi A, Chahin F, Agrawal S, Chau WY, Tootla A, Tootla F, Silva YJ (2002) Laparoscopic colectomy vs open colectomy for sigmoid diverticular disease. *Dis Colon Rectum* 45(10):1309–1315
- Purkayastha S, Constantinides VA, Tekkis PP, Athanasiou T, Aziz O, Tilney H, Darzi AW, Heriot AG (2006) Laparoscopic versus open surgery for diverticular disease: a meta-analysis of non-randomized studies. *Dis Colon Rectum* 49(4):446–463
- Tekkis PP, Senagore AJ, Delaney CP, Fazio VW (2005) Evaluation of the learning curve in laparoscopic colorectal surgery. Comparison of right-sided and left sided resections. *Ann Surg* 242:83–91
- Simons AJ, Anthone GJ, Ortega AE, Franklin M, Fleshman J, Geis WP, Beart RW Jr (1995) Laparoscopic-assisted colectomy learning curve. *Dis Colon Rectum* 38(6):600–603
- The American Society of Colon and Rectal Surgeons website. Available at: [http://www.fascrs.org/physicians/position\\_statements/laparoscopic\\_colectomy/](http://www.fascrs.org/physicians/position_statements/laparoscopic_colectomy/)
- Lange MM, Buunen M, van de Velde CJ, Lange JF (2008) Level of arterial ligation in rectal cancer surgery: low tie preferred over high tie. A review. *Dis Colon Rectum* 51:1139–1145
- Breukink SO, Pierie JPN, Hoff C, Wiggers T, Meijerink WJHJ (2006) Technique for laparoscopic autonomic nerve preserving total mesorectal excision. *Int J Colorectal Dis* 21:308–313
- Wal G (2007) Risico's minimaal invasieve chirurgie onderschat. [The Netherlands Health Care Inspectorate website]. November 2007. Available at: [http://www.igz.nl/15451/475693/2007-11\\_Rapport\\_Minimaal\\_inl.pdf](http://www.igz.nl/15451/475693/2007-11_Rapport_Minimaal_inl.pdf)
- Schwandner O, Farke S, Bruch HP (2005) Laparoscopic colectomy for diverticulitis is not associated with increased morbidity when compared with non diverticular disease. *Int J Colorectal Dis* 20:165–172
- Stefanidis D, Scerbo M, Sechrist C, Mostafavi A, Heniford T (2008) Do novices display automaticity during simulator training? *Am J Surg* 195:210–213
- Lau Leung K, Kwok SPY, Lam SCW, Lee JFY, Yiu RYC, Ng SSM, Lai PB, Lau WY (2004) Laparoscopic resection of rectosigmoid carcinoma: prospective randomised trial. *Lancet* 363:1187–1192
- Anderson J, Luchtefeld M, Dujovny N, Hoedema R, Kim D, Butcher JA (2007) Comparison of laparoscopic, hand-assist and open sigmoid resection in the treatment of diverticular disease. *Am J Surg* 193:400–403
- Contant CME, Hop WCJ, van't Sant HP, Oostvogel HJM, Smeets HJ, Stassen LPS, Neijenhuis PA, Idenburg FJ, Dijkhuis CM, Heres P, van Tets WF, Gerritsen JJ, Weidema WF (2007) Mechanical bowel preparation for elective colorectal surgery: a multicentre randomised trial. *Lancet* 370:2112–2117
- Tang R, Chen HH, Wang YL, Changchien CR, Chen JS, KC HSU, Chian JM, Wang JY (2001) Risk factors for surgical site infection after elective resection of the colon and rectum: a single-center prospective study of 2,809 consecutive patients. *Ann Surg* 234(2):181–189
- Choi HK, Law WL, Ho JWC (2006) Leakage after resection and intraperitoneal anastomosis for colorectal malignancy: analysis of risk factors. *Dis Colon Rectum* 49:1719–1725
- Buchs NC, Gervaz P, Secic M, Bucher P, Mugnier-Konrad B, Morel P (2008) Incidence, consequences, and risk factors for anastomotic dehiscence after colorectal surgery: a prospective monocentric study. *Int J Colorectal Dis* 23:265–270